Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
Luminous intensity	Tungsten lamp	Network of lamps and photometers, photometric bench	0.001	1	cd	Distribution temperature	2000 K to 3200 K	1.5 to 0.4, varies with measurand	%	2	95%	Yes	
Luminous intensity	Tungsten lamp	Network of lamps and photometers, photometric bench	1	1000	cd	Distribution temperature	2000 K to 3200 K	0.4	%	2	95%	Yes	
Luminous intensity	Tungsten lamp	Network of lamps and photometers, photometric bench	1000	100000	cd	Distribution temperature	2000 K to 3200 K	0.4 to 1.5, varies with measurand	%	2	95%	Yes	
Illuminance responsivity, tungsten source	Illuminance meter	Network of lamps and photometers, photometric bench			A/lx	Illuminance	0.001 lx to 0.1 lx	1.0 to 0.4, varies with illuminance	%	2	95%	Yes	
						Photocurrent	1E-11 A to 1E-06 A						
						Colour temperature	illuminant A						
Illuminance responsivity, tungsten source	Illuminance meter	Network of lamps and photometers, photometric bench			A/lx	Illuminance	0.1 lx to 1000 lx	0.4	%	2	95%	Yes	
						Photocurrent	1E-11 A to 1E-06 A						
						Colour temperature	illuminant A						
Illuminance responsivity, tungsten source	Illuminance meter	Network of lamps and photometers, photometric bench			A/lx	Illuminance	1000 lx to 10000 lx	0.4 to 1.5, varies with illuminance	%	2	95%	Yes	
						Photocurrent	1E-11 A to 1E-06 A						
						Colour temperature	illuminant A						
Luminous flux	Tungsten lamp	Goniophotometer	0.001	1	lm	Distribution temperature	2000 K to 3200 K	1.5	%	2	95%	Yes	

Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
Luminous flux	Tungsten lamp	Goniophotometer	1	100	lm	Distribution temperature	2000 K to 3200 K	1.5 to 0.6, varies with measurand	%	2	95%	Yes	
Luminous flux	Tungsten lamp	Goniophotometer	100	10000	lm	Distribution temperature	2000 K to 3200 K	0.6	%	2	95%	Yes	
Luminous flux	Tungsten lamp	Goniophotometer	10000	100000	lm	Distribution temperature	2000 K to 3200 K	0.6 to 1.5, varies with measurand	%	2	95%	Yes	
Illuminance	Tungsten lamp	Network of lamps and photometers, photometric bench	0.001	1	lx	Correlated colour temperature	2000 K to 3200 K	1.5 to 0.4, varies with measurand	%	2	95%	Yes	
Illuminance	Tungsten lamp	Network of lamps and photometers, photometric bench	1	1000	lx	Correlated colour temperature	2000 K to 3200 K	0.4	%	2	95%	Yes	
Illuminance	Tungsten lamp	Network of lamps and photometers, photometric bench	1000	1E+05	lx	Correlated colour temperature	2000 K to 3200 K	0.4 to 2.5, varies with measurand	%	2	95%	Yes	
Luminance	Tungsten-based source	Network of lamps and photometers, photometric bench	1	100	cd/m^2	Correlated colour temperature	2000 K to 3200 K	2.0 to 0.5, varies with measurand	%	2	95%	Yes	Area 50 mm^2 to 2500 mm^2
Luminance	Tungsten-based source	Network of lamps and photometers, photometric bench	100	2000	cd/m^2	Correlated colour temperature	2000 K to 3200 K	0.5	%	2	95%	Yes	Area 50 mm^2 to 2500 mm^2
Luminance	Tungsten-based source	Network of lamps and photometers, photometric bench	2000	2E+04	cd/m^2	Correlated colour temperature	2000 K to 3200 K	0.5 to 1.5, varies with measurand	%	2	95%	Yes	Area 50 mm^2 to 2500 mm^2
Luminance responsivity	Luminance meter	Reference lamp / diffuser combination			$A/(cd/m^2)$	Luminance	10 cd/m^2 to 100 cd/m^2	1.5	%	2	95%	Yes	Other types of sources can also be calibrated
						Type of source	tungsten lamp / diffuser combination						

Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
Luminance responsivity	Luminance meter	Reference lamp / diffuser combination			A/(cd/m^2)	Luminance	100 cd/m^2 to 1E+04 cd/m^2	0.8	%	2	95%	Yes	Other types of sources can also be calibrated
						Type of source	tungsten lamp / diffuser combination						
Responsivity, spectral, power	Broadband detector	Cryogenic radiometers and synchrotron, and laser radiation and monochromators			A/W	Wavelength	200 nm to 400 nm	1.0	%	2	95%	Yes	
						Radiant power	< 4 µW						
						Bandwidth	2.5 nm						
Responsivity, spectral, power	Broadband detector	Double grating monochromator			A/W	Wavelength	400 nm to 800 nm	0.3	%	2	95%	Yes	
						Bandwidth	5 nm to 20 nm						
						Power level	0.1 µW to 10 µW						
Responsivity, spectral, power	Broadband detector	Double grating monochromator			A/W	Wavelength	800 nm to 1000 nm	0.9	%	2	95%	Yes	
						Bandwidth	5 nm to 20 nm						
						Power level	0.1 µW to 10 µW						
Responsivity, spectral, power	Broadband detector	Double grating monochromator			A/W	Wavelength	1000 nm to 1600 nm	1.5	%	2	95%	Yes	
						Bandwidth	5 nm to 20 nm						
						Power level	0.1 µW to 10 µW						
Responsivity, laser, power	General detector	Comparison with primary standard			A/W, V/W, reading/W	Wavelength	10.6 µm	0.3 to 1.0, varies with power level	%	2	95%	Yes	
						Power level	0.1 W to 1500 W						

Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
Responsivity, laser, power	General detector	Comparison with primary standard			A/W, V/W, reading/W	Wavelengths	laser lines between 308 nm and 1064 nm	0.2 to 1.0, varies with power level	%	2	95%	Yes	
						Power level	1 µW to 120 W						
Responsivity, laser, power	General detector	Comparison with primary standard			V/W or Reading/ W	Wavelengths	2106 nm and 2936 nm	1	%	2	95%	Yes	
						Power level	0.01 W to 10 W						
Responsivity, laser, power	General detector	Comparison with primary standard	0.01	10	W	Wavelength	351 nm	1.0	%	2	95%	Yes	Excimer laser lines, average power Approved on 07 May 2007
Responsivity, laser, power	General detector	Comparison with primary standard	0.01	20	W	Wavelength	308 nm	1.0	%	2	95%	Yes	Excimer laser lines, average power Approved on 07 May 2007
Responsivity, laser, power	General detector	Comparison with primary standard	0.01	30	W	Wavelength	248 nm	1.0	%	2	95%	Yes	Excimer laser lines, average power Approved on 07 May 2007

Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
Responsivity, laser, power	General detector	Comparison with primary standard	0.01	3	W	Wavelength	193 nm	1.0	%	2	95%	Yes	Excimer laser lines, average power Approved on 07 May 2007
Responsivity, laser, power	General detector	Comparison with primary standard	0.01	3	W	Wavelength	157 nm	2.0	%	2	95%	Yes	Excimer laser lines, average power Approved on 07 May 2007
Irradiance, spectral	Tungsten lamp	Spectroradiometer	1E-04	0.25	$(W/m^2)/nm$	Wavelength	250 nm to 270 nm	12 to 5, varies with wavelength	%	2	95%	Yes	
						Bandwidth	0.5 nm to 20 nm						
Irradiance, spectral	Tungsten lamp	Spectroradiometer	1E-04	0.25	$(W/m^2)/nm$	Wavelength	270 nm to 400 nm	5 to 1.6, varies with wavelength	%	2	95%	Yes	
						Bandwidth	0.5 nm to 20 nm						
Irradiance, spectral	Tungsten lamp	Spectroradiometer	1E-04	0.25	$(W/m^2)/nm$	Wavelength	400 nm to 800 nm	1.6	%	2	95%	Yes	
						Bandwidth	0.5 nm to 20 nm						
Irradiance, spectral	Tungsten lamp	Spectroradiometer	1E-04	0.25	$(W/m^2)/nm$	Wavelength	800 nm to 2000 nm	1.6 to 3, varies with wavelength	%	2	95%	Yes	
						Bandwidth	0.5 nm to 20 nm						
Irradiance, spectral	Tungsten lamp	Spectroradiometer	1E-04	0.25	$(W/m^2)/nm$	Wavelength	2000 nm to 2500 nm	3 to 5, varies with wavelength	%	2	95%	Yes	
						Bandwidth	0.5 nm to 20 nm						

Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
Irradiance, spectral	Deuterium lamp	Spectroradiometer	1E-05	0.02	$(W/m^2)/nm$	Wavelength	200 nm to 300 nm	10 to 4, varies with wavelength	%	2	95%	Yes	
						Bandwidth	4 nm						
Irradiance, spectral	Deuterium lamp	Spectroradiometer	1E-05	0.02	$(W/m^2)/nm$	Wavelength	300 nm to 400 nm	4 to 8, varies with wavelength	%	2	95%	Yes	
						Bandwidth	4 nm						
Radiance, spectral	Tungsten lamp	Spectroradiometer	5E-03	3E+02	$W/(m^2\ sr\ nm)$	Wavelength range	250 nm to 650 nm	13.0 to 2.0, varies with wavelength	%	2	95%	Yes	
						Bandwidth	< 2 nm						
Radiance, spectral	Tungsten lamp	Spectroradiometer	5E-03	3E+02	$W/(m^2\ sr\ nm)$	Wavelength range	650 nm to 2500 nm, < 2 nm	2.0 to 6.0, varies with wavelength	%	2	95%	Yes	
						Bandwidth	< 2 nm						
Radiance, spectral	Deuterium lamp	Spectroradiometer	1	1E+03	$W/(m^2\ sr\ nm)$	Wavelength range	200 nm to 350 nm	4	%	2	95%	Yes	
						Bandwidth	0.2 nm						
Radiant intensity, spectral	Deuterium lamp	Spectroradiometer	1E-06	1E-03	W/(sr nm)	Wavelength range	200 nm to 350 nm	4	%	2	95%	Yes	
						Bandwidth	0.2 nm						
Transmittance, regular, spectral	Spectrally-neutral material	Direct/ cascading	1E-06	1		Wavelength	380 nm to 1000 nm	0.3(1 - log$t$), t transmittance	%	2	95%	Yes	
						Bandwidth	0.1 nm to 16 nm						
Reflectance, diffuse, spectral	Spectrally-neutral material	Absolute sphere reflectometer	0.1	1		Wavelength	360 nm to 830 nm	0.2	%	2	95%	Yes	
						Bandwidth	3 nm						
						Geometry	d/0, d/8						

Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
Reflectance, diffuse, spectral	Spectrally-neutral material	Absolute sphere reflectometer	0.1	1	1	Wavelength range	300 nm to 360 nm	0.5 to 0.2, varies with wavelength	%	2	95%	Yes	
						Bandwidth	> 3 nm						
						Specific measurement conditions	d/0 and d/8						
Reflectance, diffuse, spectral	Spectrally-neutral material	Absolute sphere reflectometer	0.1	1	1	Wavelength range	830 nm to 1100 nm	0.2 to 0.5, varies with wavelength	%	2	95%	Yes	
						Bandwidth	> 3 nm						
						Specific measurement conditions	d/0 and d/8						
Reflectance, regular, spectral	Spectrally-neutral material	Reference reflectometer	0.01	1		Wavelength range	220 nm to 20 µm	0.005 to 0.02, varies with wavelength and measurand		2	95%	No	Material with smooth surface
						Angle of incidence	7° to 80°						
						Spectral bandwidth	0.1 nm to 16 nm						
Reflectance, regular, spectral	Spectrally-neutral material	Gonioreflectometer	0.01	1		Wavelength range	10 nm to 30 nm	0.28 to 2, varies with value and wavelength	%	2	95%	Yes	Approved on 07 May 2007
BRDF	General material	Gonio-reflectometer	0.1	1		Wavelength range	300 nm to 400 nm	1.0 to 0.4, varies with wavelength	%	2	95%	Yes	Spectrally-neutral material
						Bandwidth	> 3 nm						

Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
						Angle of incidence / reflectance	0° to 85°						
BRDF	General material	Gonio-reflectometer	0.1	1		Wavelength range	400 nm to 850 nm	0.4	%	2	95%	Yes	Spectrally-neutral material
						Bandwidth	> 3 nm						
						Angle of incidence / reflectance	0° to 85°						
BRDF	General material	Gonio-reflectometer	0.1	1		Wavelength range	850 nm to 1100 nm	0.4 to 1.4, varies with wavelength	%	2	95%	Yes	Spectrally-neutral material
						Bandwidth	> 3 nm						
						Angle of incidence / reflectance	0° to 85°						
BRDF	General material	Gonio-reflectometer	0.03	infinite	1/sr	Wavelength range	250 nm to 900 nm	3.5 to 0.4, varies with wavelength	%	2	95%	Yes	Approved on 07 May 2007
						Bandwidth	3 nm						
						Geometry	arbiratry						
BRDF	General material	Gonio-reflectometer	0.03	infinite	1/sr	Wavelength range	900 nm to 1700 nm	0.4 to 0.5, varies with wavelength	%	2	95%	Yes	Approved on 07 May 2007
						Bandwidth	6 mm						
						Geometry	arbitrary						
Reflectance factor	Spectrally-neutral material	DMC 25 / Lambda900 - spectrometer	0.001	1		Wavelength range	300 nm to 2000 nm	1	%	2	95%	Yes	
						Bandwidth	5 nm to 10 nm						

Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
Radiance factor	General material	Gonio-reflectometer	0.1	1		Wavelength range	300 nm to 400 nm	1.0 to 0.4, varies with wavelength	%	2	95%	Yes	Spectrally-neutral material
						Bandwidth	> 3 nm						
						Geometry	0/45 and 45/0						
Radiance factor	General material	Gonio-reflectometer	0.1	1		Wavelength range	400 nm to 850 nm	0.4	%	2	95%	Yes	Spectrally-neutral material
						Bandwidth	> 3 nm						
						Geometry	0/45 and 45/0						
Radiance factor	General material	Gonio-reflectometer	0.1	1		Wavelength range	850 nm to 1100 nm	0.4 to 1.4, varies with wavelength	%	2	95%	Yes	Spectrally-neutral material
						Bandwidth	> 3 nm						
						Geometry	0/45 and 45/0						
Radiance factor	General material	Gonio-reflectometer	0.01	infinite		Wavelength range	250 nm to 900 nm	3.5 to 0.4, varies with wavelength	%	2	95%	Yes	Approved on 07 May 2007
						Bandwidth	3 nm						
						Geometry	0/45 and 45/0						
Radiance factor	General material	Gonio-reflectometer	0.01	infinite		Wavelength range	900 nm to 1700 nm	0.4 to 0.5, varies with wavelength	%	2	95%	Yes	Approved on 07 May 2007
						Bandwidth	6 nm						
						Geometry	0/45 and 45/0						
Radiance factor	Fluorescent material	Two-monochromator spectrometer	0.001	3.0		Wavelength range	300 nm to 800 nm	3	%	2	95%	Yes	
						Bandwidth	5 nm to 10 nm						

Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
Wavelength	Spectrally-selective transmitting material. Position of transmittance minimum	Reference spectrometer	240	653	nm	Wavelength	240 nm to 653 nm	0.15 to 0.3, varies with bandwidth	nm	2	95%	No	Approved on 07 May 2007
						Bandwidth	0.1 nm to 3 nm						
Distribution temperature	Tungsten lamp	Spectral distribution	2000	2350	K			20 to 10, varies with measurand	K	2	95%	No	
Distribution temperature	Tungsten lamp	Spectral distribution	2350	3000	K			10	K	2	95%	No	
Distribution temperature	Tungsten lamp	Spectral distribution	3000	3200	K			20	K	2	95%	No	
Correlated colour temperature	Tungsten lamp	Spectral distribution	2000	2350	K			10 to 6, varies with measurand	K	2	95%	No	
Correlated colour temperature	Tungsten lamp	Spectral distribution	2350	3000	K			6	K	2	95%	No	
Correlated colour temperature	Tungsten lamp	Spectral distribution	3000	3200	K			10	K	2	95%	No	
Colour, emitted, x, y	General source	Standard lamps with spectroradiometer	0	0.9		Bandwidth	broad band (> 100 nm)	0.001 to 0.0005, varies with measurand	%	2	95%	No	
Colour, emitted, x, y	General source	Standard lamps with spectroradiometer	0	0.9		Bandwidth	narrow band (< 100 nm)	0.005 to 0.0005, varies with measurand		2	95%	No	

Photometry and Radiometry, Germany, PTB (Physikalisch-Technische Bundesanstalt)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty					
Quantity	**Instrument or Artifact**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**Comments**
Responsivity	Fibre optic power meter	Comparison with standard detector			A/W or Reading/ W	Wavelengths	650 nm, 850 nm, 1300 nm, 1550 nm	0.3 to 0.6, varies with power	%	2	95%	Yes	
						Power	1 nW to 3 mW						
Wavelength	Fibre optic source	Wavemeter	400	1100	nm	Power level	> 0.5 mW	1	pm	2	95%	No	
						Laser bandwidth	< 1 nm						
Wavelength	Fibre optic source	Wavemeter	1100	1600	nm	Power level	> 0.5 mW	3	pm	2	95%	No	
						Laser bandwidth	< 1 nm						